PROGRESS AND PLANS OF NATIONAL NANOTECHNOLOGY INITIATIVE (NNI) AGENCIES

February 2018

Department of Health and Human Services (DHHS)

National Institute for Occupational Safety and Health (NIOSH)

Summary

The National Institute for Occupational Safety and Health provides national and world leadership in conducting research on the causes and prevention of work-related illness and injury. NIOSH is a leader in the Federal Government's research initiative on understanding the potential occupational health and safety implications of nanotechnology, and its possible applications to solve current worker health and safety issues. NIOSH research advances the understanding of nanotechnology-related toxicology and workplace exposures, so that appropriate risk management practices can be implemented during the discovery, development, and commercialization of engineered nanomaterials along their product life cycles. Through strategic planning, research, collaborating with stakeholders, and making information widely available, NIOSH develops guidance that supports and promotes the safe and responsible development of nanomaterials.

Key Technical Accomplishments by NNI Goal

Goal 4. Support Responsible Development of Nanotechnology

NIOSH Accomplishments for January–December 2017

NIOSH staff members published 101 peer-reviewed journal articles, including a seminal document addressing the toxicology of a nanomaterial along its life cycle: An *In-Vivo* Toxicity Assessment of Occupational Components of the Carbon Nanotube Life Cycle to Provide Context to Potential Health Effects,[1] and another seminal article describing a quantitative framework for categorizing nanomaterials by hazard potency.[2] This second article contributed to the strategic goals of developing algorithms to derive occupational exposure limits for nanomaterial groups and predicting potency groups of new nanomaterials from their physicochemical properties. NIOSH published its first toxicology paper pertaining to an emerging advanced manufacturing technology, three-dimensional (3D) printing: Inhalation Exposure to Three-Dimensional Printer Emissions Stimulates Acute Hypertension and Microvascular Dysfunction[3] and published a Health Hazard Evaluation report on Emission of Particulate Matter from a Desktop Three-Dimensional Printer,[4] one of the first NIOSH field evaluations pertaining to nanoparticles emitted by 3D

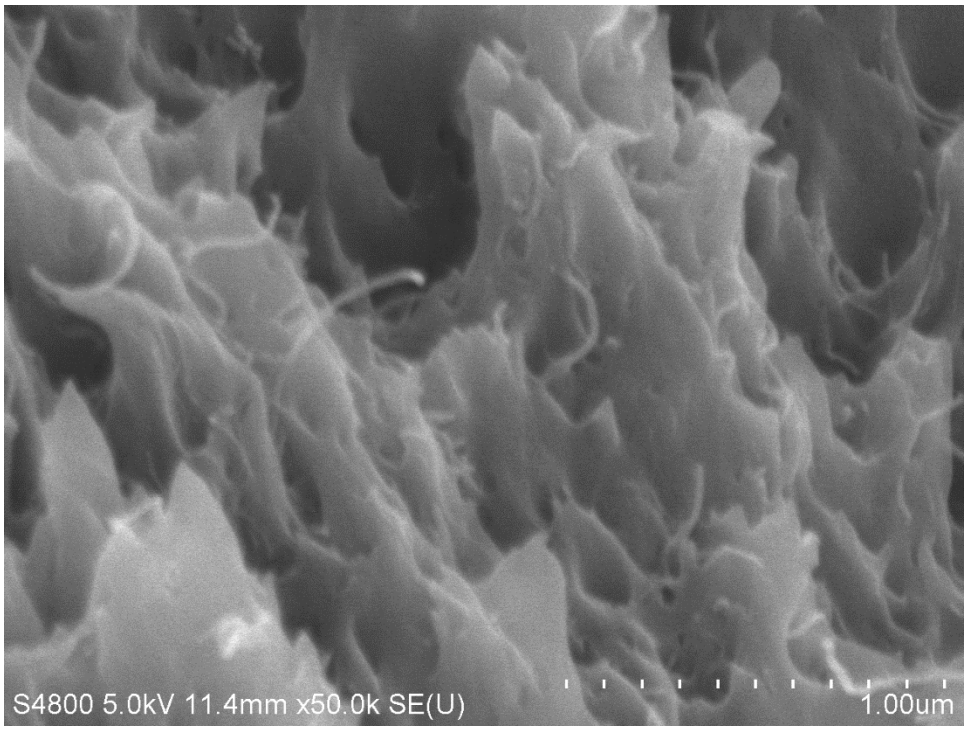
[1] https://www.ncbi.nlm.nih.gov/pubmed/28759202

[2] https://www.ncbi.nlm.nih.gov/pubmed/28789940

[3] https://www.ncbi.nlm.nih.gov/pubmed/28942003

[4] https://www.cdc.gov/niosh/hhe/reports/pdfs/2017-0059-3291.pdf

printing. NIOSH will be evaluating the potential impact on worker exposures from the use of engineered nanomaterials in 3D printing. An example of one material is shown below.



Polycarbonate filament for use in a 3D printer that shows MWCNT protruding from the surface of the unused product. Photo: Alycia Knepp (NIOSH)

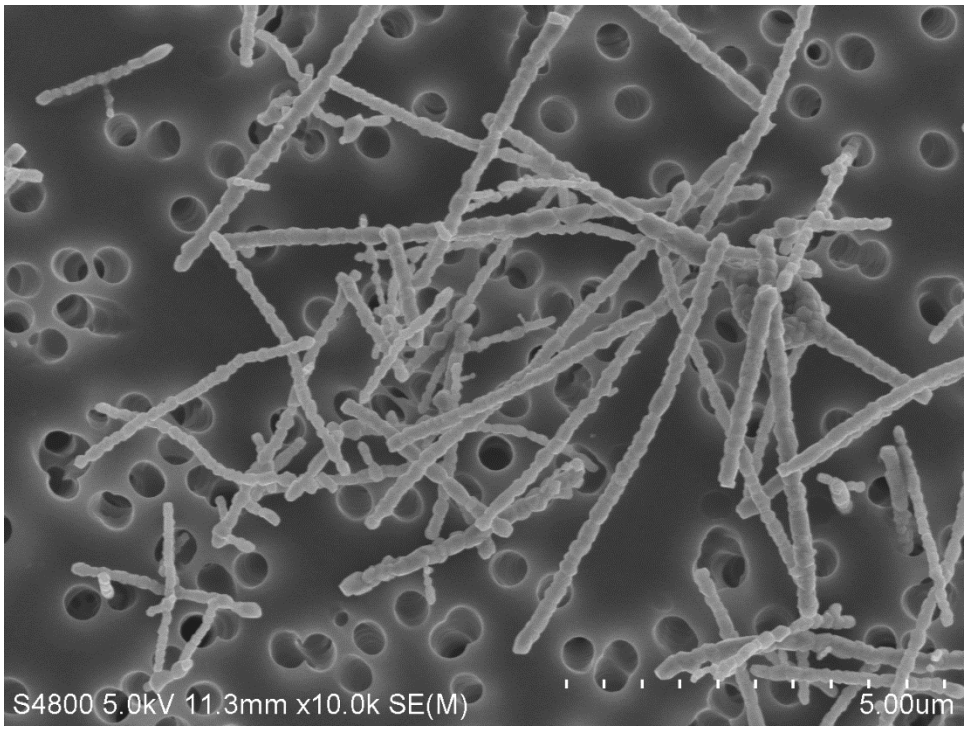
In response to a critical needed expressed by the nanomanufacturing EHS community, NIOSH published a new chapter in the *NIOSH Manual of Analytical Methods*: Analysis of Carbon Nanotubes and Nanofibers on Mixed Cellulose Ester Filters by Transmission Electron Microscopy.[5]

NIOSH chaired the committee and provided major contributions to the development and publication of the National Council on Radiation Protection and Measurements (NCRP) Report No. 176 on Radiation Safety Aspects of Nanotechnology.[6]

NIOSH continues its efforts to develop more complete hazard and safety assessments using key classes of engineered nanomaterials, including carbon nanotubes; metal oxides; silver; the nanowire forms of silver, silica, and titania; graphene and graphene oxide; and cellulose nanocrystals and nanofibers. In 2017–2018, NIOSH continued its efforts to develop "real world" evaluations of hazard and risk represented by various nanomaterials through their life cycles. NIOSH characterized 22 commercially available spray products that advertised the use of nanosilver or colloidal silver as the active ingredient.

[5] https://www.cdc.gov/niosh/nmam/pdf/chapter-cn.pdf

[6] https://www.ncrppublications.org/Reports/176



TiO_2 nanowires on a track-etched polycarbonate filter. Photo: Diane Schwegler-Berry (NIOSH)

NIOSH Collaborative Accomplishments

NIOSH, CPSC, NIST, EPA, and private sector companies:[7] These agencies are developing ASTM test methods for quantification of silver in textiles (begun in 2016 and extended into 2018).

NIOSH, FDA, NIST, EPA, U.S. private sector companies, and international metrology institutes in Asia and Europe: This group of international experts has been developing international protocols for determination of nanoparticle size and size distribution for numerous morphologies (spheres, rods, cubes, bipyramids, and primary particles) of industrially-relevant metal and metal oxide nanomaterials that will be disseminated as International Organization for Standardization (ISO) standards (undertaken several years ago and continued through 2018 and beyond).

NIOSH and standards developing organization: NIOSH contributed to the ISO standard, *TR 19057:2017 Nanotechnologies — Use and application of acellular* in vitro *tests and methodologies to assess nanomaterial biodurability*.[8]

NIOSH and WHO: The World Health Organization (WHO) published its guidelines on nanomaterial safety in the workplace in fiscal year (FY) 2018. NIOSH led the development of these guidelines and was actively involved in all aspects of this effort: conducting one of the systematic reviews, developing recommendations, and providing critical expert review.

NIOSH and CPSC: NIOSH and CPSC collaborated to characterize, quantify, and identify exposures from airborne nanomaterials (CNTs, graphene, and metal oxides) released from products and 3D printers.

[7] See https://www.nano.gov/partners for a list of NNI participating agencies and their abbreviations.

[8] https://www.iso.org/standard/63836.html

NIOSH and industry: To fully understand the potential health and safety impacts of nanotechnology, NIOSH utilizes field research teams that visit nanomaterial producers and users and conduct industrial hygiene evaluations. During 2017, NIOSH collaborated with 8 companies and completed 12 field assessments. The field team expanded into facilities that were utilizing nanomaterials for additive manufacturing, including 3D printing.

NIOSH and CPWR: In 2017-2018 NIOSH and the Center for Construction Research and Training (CPWR) continued collaborations to promote responsible development and effective risk management of nanotechnology-enabled products in the U.S. construction industry, and co-authored a chapter: Managing Occupational Exposure to Engineered Nanomaterials in Construction in the USA for the SCAFFOLD European Union Seventh Framework Programme (in press 2018). CPWR also provided dust generated from sanding nanotechnology-enabled wood products to NIOSH for toxicological testing.

NIOSH and AIHA: NIOSH collaborated with the American Industrial Hygiene Association (AIHA) to provide a half-day professional development course on Risk Management and Exposure Assessment of Nanomaterials. During 2017, this class was presented at the national AIHA conference and at a local section meeting to 60 individuals. This class was accepted for presentation at the 2018 AIHA national conference.

NIOSH and UAW: NIOSH presented the professional development course on Risk Management and Exposure Assessment of Nanomaterials to 40 individuals during the United Auto Workers (UAW) 2017 annual safety conference at Black Lake, MI.

NIOSH, SUNY Poly, and industry: NIOSH and SUNY Poly have identified private-sector organizations that have expressed interest in a public-private partnership to promote safe practices in nanotechnology and advanced manufacturing. A kick-off session was part of the TechConnect World Innovation Conference and Expo in 2017, and a follow-up session was accepted for TechConnect 2018.

NIOSH and international organizations: NIOSH continued to partner with multiple European organizations on a dustiness testing ("DUST") scheme coordinated by the UK Health and Safety Laboratory (HSL), comparing "dustiness" (i.e., particle release with respect to inhalation exposure) evaluation methods for a limited set of high-commercial-use fine and nanoscale materials.[9] The collaborating organizations are exploring the utility of dustiness as a metric for risk management decision making. In addition, NIOSH continued to participate in the Organisation for Economic Cooperation and Development (OECD), including the Risk Assessment and Regulatory Programmes Steering Group and the working group evaluating adverse outcome pathway information for nanomaterial risk assessment and categorization.

NIOSH and academia: NIOSH collaborated with over 20 national and international universities in the characterization of toxicological effects of pulmonary and dermal exposure to a wide range of industrially relevant nanoparticles and nanotechnology-enabled materials.

[9] https://www.hsl.gov.uk/online-ordering/analytical-services-and-assays/fibres/dustiness-testing

Plans and Priorities by Program Component Area (PCA)

PCA 5. Environment, Health, and Safety

NIOSH Plans for 2018–2019

- Finalize the Current Intelligence Bulletin (CIB) on *Health Effects of Occupational Exposure to Silver Nanomaterials*.[10]
- Release the draft CIB, *Approaches to Developing Occupational Exposure Limits or Bands for Engineered Nanomaterials*.
- Publish information on individual process-based control strategies (Workplace Design Solutions) to promote effective and sustainable engineering controls.
- Continue to utilize the principles of research to practice in developing occupational safety and health guidance that can be incorporated into an organization's business plan in a way that worker safety is protected and, in turn, more rapid application development and commercialization can be realized.
- Continue with evaluation of nanomaterial producers and users with an emphasis on advanced manufacturing, including 3D printing.
- Continue investment in the development, testing, and evaluation of direct-reading instruments capable of detecting and measuring airborne nanoparticles. Continue field tests of the portable aerosol multielement spectrometer developed by NIOSH at nanomaterial producer and user facilities.
- Continue efforts in detection of airborne nanoparticles into specific applications in the areas of detection of nanomaterials in biologic systems to evaluate and predict biological behavior and translocation between organ systems.
- Evaluate the feasibility of applying advanced sensing technology to biomarkers as a means of evaluating nanomaterial exposure and possible early response in support of ongoing nanomaterial worker surveillance.
- Continue with individual projects evaluating biomarkers, cardiovascular toxicity, pulmonary exposure, dermal and immune response to nanoclays, boron nitride nanotubes, and 2D nanomaterials, evaluation of copper nanoparticles in dust from treated wood, toxicity investigation of nanotechnology-enabled construction materials, and the generation and characterization of aerosols from nanocomposites.

NIOSH Collaborative Plans

NIOSH, other NNI agencies, and standards developing organization: In 2019, NIOSH will continue leading the development of ISO *TR 12885 — Health and safety practices in occupational settings relevant to nanotechnologies*, which aims to ensure that workers handling nanomaterials are protected not only in the United States, but also in countries around the world.

NIOSH and CPSC: NIOSH will continue with the study of engineered nanomaterial emissions (e.g., carbon nanotubes, graphene) from 3D printers and *in vitro* and *in vivo* toxicology studies during 2018–2019.

NIOSH and industry: In 2019, NIOSH will continue its efforts to develop practical, "real world" evaluation of hazard and risk represented by various nanomaterials through their life cycles. The NIOSH field research effort will focus on outputs that support the Sustainable Nanomanufacturing NSI along the life cycles of nanomaterials, including advanced manufacturing and evaluation of potential emissions from 3D printers.

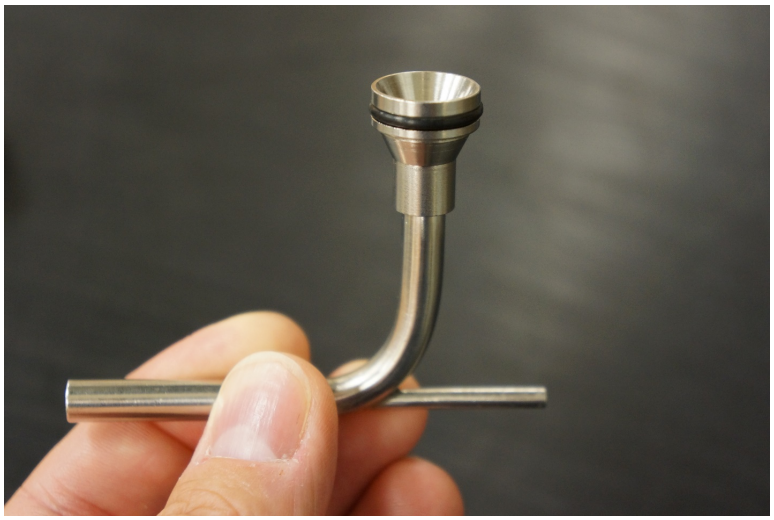
[10] https://www.cdc.gov/niosh/docket/review/docket260a/pdfs/draft--niosh-cib-on-silver-nanomaterials-1_8_16.pdf

NIOSH has secured partnerships with large companies that have expressed strong interest in having the NIOSH nanotechnology field research team evaluate 3D printing and the use of robotics. NIOSH will collaborate with industry (both domestic and international) to continue the toxicology lifecycle project for carbon-based, metal-based, and nanoclay-enabled materials as well. NIOSH will continue collaborations to evaluate a thermophoretic sampler at various nanomaterial producer and user facilities.

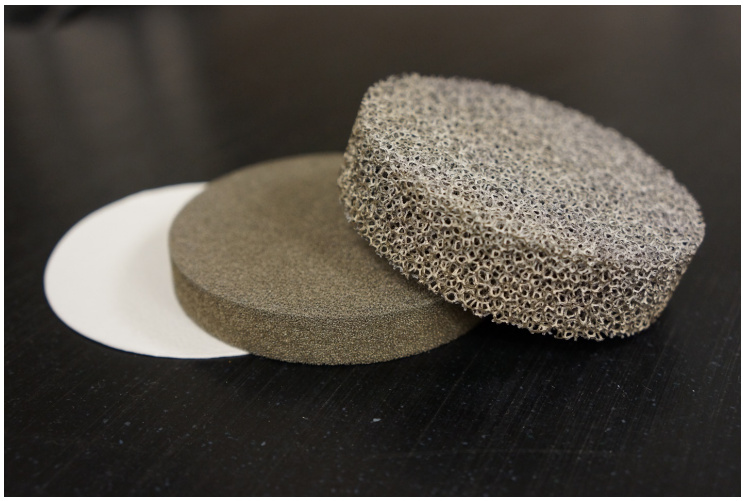
NIOSH, SUNY Poly, and industry: NIOSH and SUNY Poly have plans for continued collaboration in advanced manufacturing during 2018–2019 to promote safe practices in nanotechnology and advanced manufacturing. A session was accepted for TechConnect World Innovation Conference and Expo in 2018, and an in-depth multi-day meeting is being planned for 2019 at SUNY Poly.

NIOSH and CPWR: NIOSH will continue collaborations to evaluate a number of zinc- and titanium-enabled sprays and treated surfaces.

NIOSH Research Highlights



The dispersion nozzle from the NIOSH Venturi dustiness testing device. The nozzle is loaded with milligram quantities of fine and nanoscale powdered materials and subsequently dispersed within the Venturi device. Materials may be compared by their dispersion potential (dustiness). Photo: Doug Evans (NIOSH)



Dust collection media from within the EN15051 rotating drum dustiness testing device. These size-selective media, consisting of two metallic foams and filter, provide the inhalable, thoracic, and respirable fractions of generated dust from fine and nanoscale powders. Photo: Doug Evans (NIOSH).